INTERCOMPARISON OF FIELD METHODS FOR ACQUIRING GROUND REFLECTANCE AT RAILROAD VALLEY PLAYA FOR SPECTRAL CALIBRATION OF SATELLITE DATA

Ian C. Lau, Cindy C. H. Ong, Carolina Barrientos, Kurt J. Thome, Andreas Mueller, Uta Heiden, Jeff Czapla-Myers, Stuart Biggar, Nikolaus Anderson, Lorcan McGonigle, William Thomas, Yuki Itoh, Brian Wenny.

Dr Cindy Ong| Principal Research Scientist, CSIRO Energy

23rd of July 2018

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Collaborators

- Commonwealth Scientific Industrial Research Organisation (CSIRO), Australia
- National Aeronautics and Space Administration (NASA) Goddard Space Flight Centre, U.S.A.
- Aerial Photogrammetric Service (SAF), Chilean Air Force, Chile
- German Aerospace Center (DLR), Germany
- Remote Sensing Group, College of Optical Sciences, University of Arizona, U.S.A.
- Spaceflight Industries, U.S.A.
- University of Massachusetts Amherst, USA

GSIS

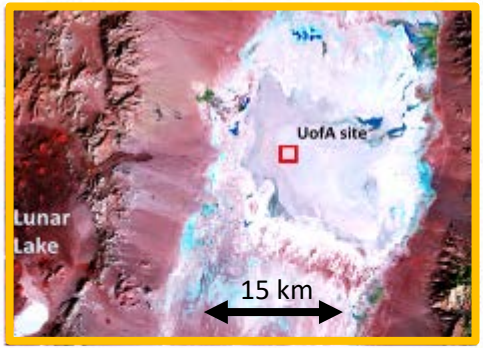
- This field exercise was funded by the IEEE Geoscience & Remote Sensing Society as part the Geoscience Spaceborne Imaging Spectroscopy (GSIS) Technical Committee Calibration and Validation initiative. We gratefully acknowledge their support.

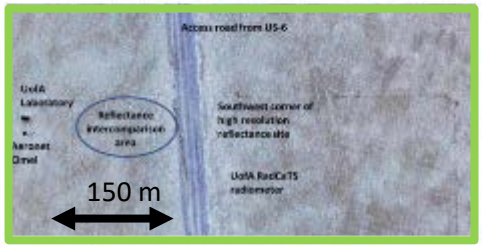
Rational

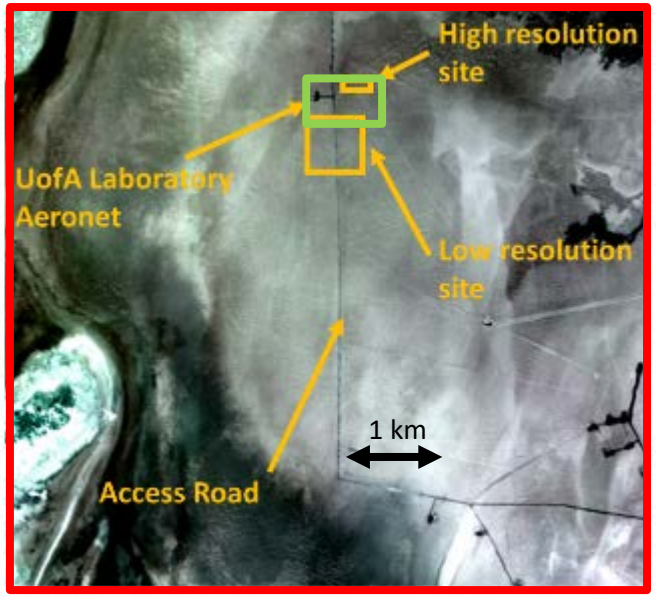
- The purpose of this research was a learning exercise for scientists and engineers undertaking work in the field of remote sensing instrumentation calibration and validation.
- The exercise included a tour of an optical calibration lab operated by the Remote Sensing Group (RSG) at the University of Arizona (UofA).
- The field component was to perform a surface reflectance inter-comparison of different methods of collection at a RadCalNet site (Railroad Valley Play, Nevada USA).
- The target was to perform a reflectance-based calibration of an on-orbit satellite sensor (Sentinel 2) with the data collected if the conditions were good.

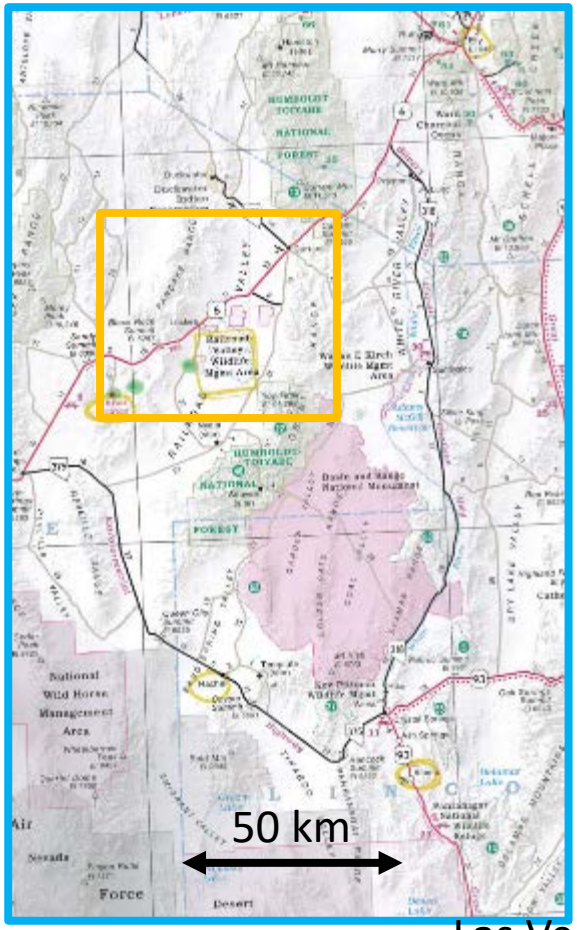
Location

- Railroad Valley Playa, Nevada U.S.A.
- 31st July, 1st and 2nd of August 2017









Method

- Two sites at RRVP
  - 80 m E-W transect for experiments
  - High resolution cal-val site used by RSG UofA and NASA
- Three teams of two people
  - Spectroradiometer operator
  - Note taker/spotter/reference panel operator
  - Teams consisted of a mixture of levels of field spectroradiometer experience
- Spectral collection methods
  - Stop and collect
  - Moving transects

Instrumentation

- Spectroradiometers
  - ASD FieldSpec 4, Serial number: 18497_1
  - ASD FieldSpec, Serial number: 687_7
- Reference Panels
  - Two 99% reflectance Spectralon 20 inch (500 mm) panels on custom 3 legged mounts, ~500 mm from the surface (Serial: S6 and S7).
- RadCaTS and Ancillary instruments
  - CIMEL sun photometer
  - Weather station
  - Ground viewing radiometers (GVR)
  - CaTSSITR transfer radiometer

Measurement notes

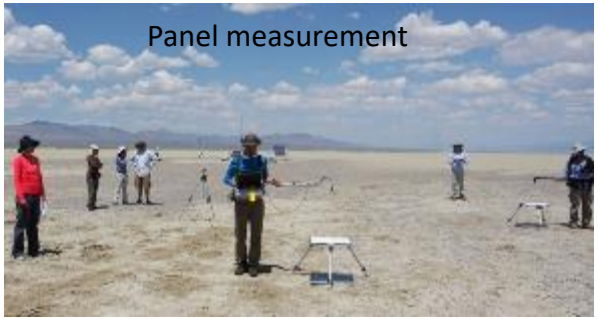
- Spectroradiometer was optimised at the start of the experiment before saving spectra over the reference panel. There is a potential for saturation of the spectroradiometer due to changing light conditions during the experiments if the collection takes a significant time.
- The reference panel was aligned to be orientated so a specific edge was always normal to the sun. The panel was also calibrated for reflectance factor at different angles based on the specific edge by the RSG at UofA.
- The reference panel was carefully levelled each time it was moved.
- A pole with the 8 degree foreoptic was held perpendicular to operator out to the south at around hip height and swapped over on the return path.

Experiment 1: Repeatability measurements

- Determine the repeatability and accuracy of multiple users measuring the same 80 m linear transect over multiple collections.
- Collection of 32 spectra (average of 20 scans per spectra) walking east for 80 m, then returning the same transect walking west collecting 20 measurements.
- Panel measurements (8 spectra) before and after the transect.

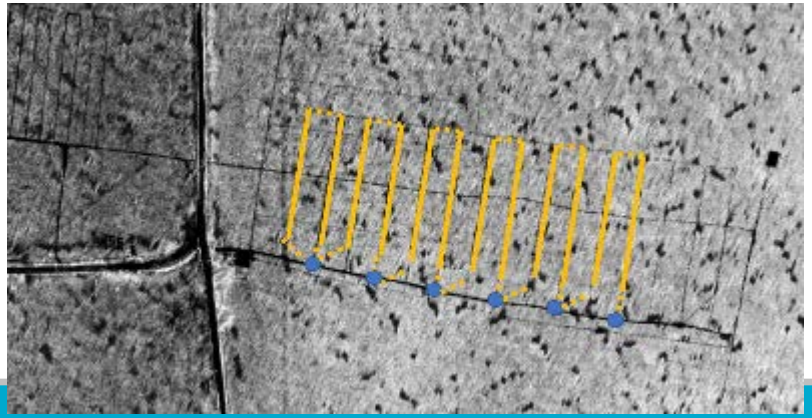
Experiment 2: Measurement method comparison

- Comparison of the moving collection (continuous) method versus a stop and measure method.
- Collect data on the same transect as the repeatability test. 8 spectra (average of 20 scans) performed every 10 m in one direction only and a panel reference measurement collected at the start and after each surface measurement.



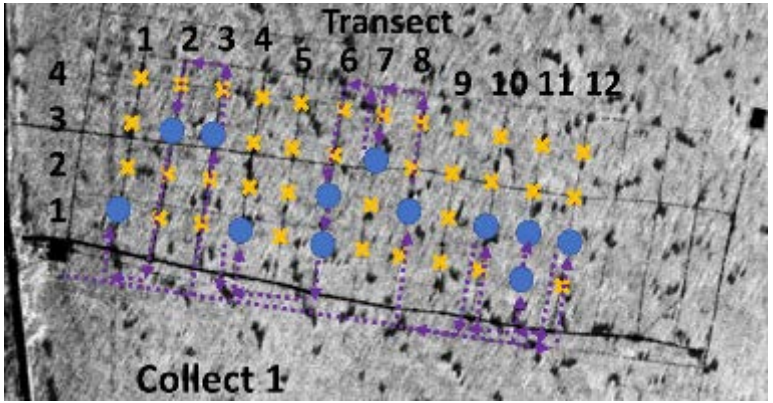
Experiment 3: Reflectance-based calibration method -1

- North-south transects. Walking north along first transect and south along second transect, returning to reference panel.
- Transects are 20 m apart.
- Reference panel measurement, relocated at the southern end, at the start and every second transect.



Experiment 3: Reflectance-based calibration method -2

- Stop and measure (S&M) along the north-south transects. 12 stop collects taken throughout the area. Panel is moved and set up before each measurement
- Reference panel measurement before each measurement.



Results

- Reflectances for each spectra were calculated by applying the specifc reflectance factor for the panels (measured at RSG UofA's lab) for the illumination angle of the sun.
- Wavelengths in the 1346-1447 nm, 1800-1965 nm and 2432-2500 nm regions were removed from calculation of the averages, standard deviations and coefficient of variations.

Experiment 1 : Continuous measurement

- 12 runs over 3 hours by 7 operators using 2 spectroradiometers and 2 panels.
- ~3% variability between the average reflectance of all the runs, reduced after the data was mean-normalised.
- Instrument dependant variations seen between the spectroradiometers

Experiment 1: Continuous measurement

Run	Code	Indiv. Coll. CV %
1	E1_ASD1_P7_OP1_R1	3.23
2	E1_ASD2_P6_OP2_R1	3.88
3	E1_ASD1_P7_OP3_R1	3.41
4	E1_ASD1_P7_OP4_R1	3.37
5	E1_ASD1_P7_OP5_R1	3.99
6	E1_ASD1_P7_OP1_R2	3.01
7	E1_ASD2_P6_OP2_R2	2.78
8	E1_ASD1_P7_OP3_R2	3.49
9	E1_ASD2_P6_OP6_R1	3.48
10	E1_ASD1_P7_OP4_R2	2.59
11	E1_ASD1_P7_OP5_R2	4.64
12	E1_ASD1_P7_OP7_R1	3.17
Average CV for Individual Collections		**3.42**
SD		0.56

- 12 Collects by 7 operators along E-W 80m transect.
- Good solar conditions, low amount of wind, >37°C temperatures.
- Some operators first time using this type of field spectroradiometer

Key:
E – Experiment
ASD – Spectroradiometer number
P – Panel number
OP – Operator
R – Run number

CV – Coefficient of variation
SD – Standard deviation

Experiment 1: Comparison of operators

- Operators ranged in experience with operation of field spectroradiometers.
- The coefficients of variance (CV) for each operator for 2 runs were compared. Experiment (Exp) 2 continuous measurements were also included.
- **Not enough data was obtained (3 runs in total if Experiment 2 data was included) to produce meaningful results.**
- However, inexperienced operators were able to produce low CV data.
- Inexperienced operators CV lowered when both Exp 1 and Exp 2 (day 2) data was combined, while the more experienced operators CV increased, which could be partly due to changing weather conditions.

OP	AVE E1	AVE Exp1 & Exp2
OP1	3.12	3.50
OP2	3.33	3.14
OP3	3.45	3.37
OP4	2.98	3.43
OP5	4.31	3.79
OP6	-	3.91
OP7	-	-

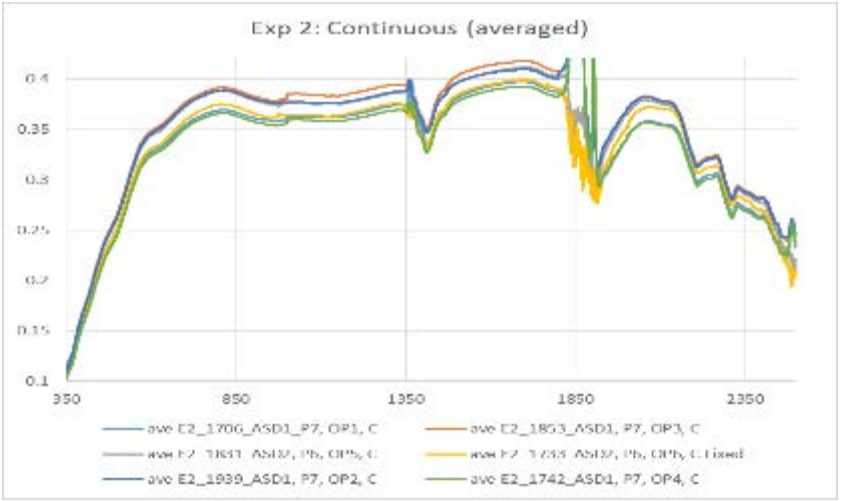
Experiment 1: Comparison of Spectroradiometers

- The deviation from the mean reflectance shows that there was a difference between the two spectroradiometers/panels.
- Overall the comparison of CVs for the 2 spectroradiometers shows similar values for Exp 1 and Exp 2 continuous measurements.

Instrument	CV
Exp1 ASD1	3.43
Exp1 ASD2	3.38
Exp1 and Exp2 ASD1	3.50
Exp1 and Exp2 ASD2	3.44

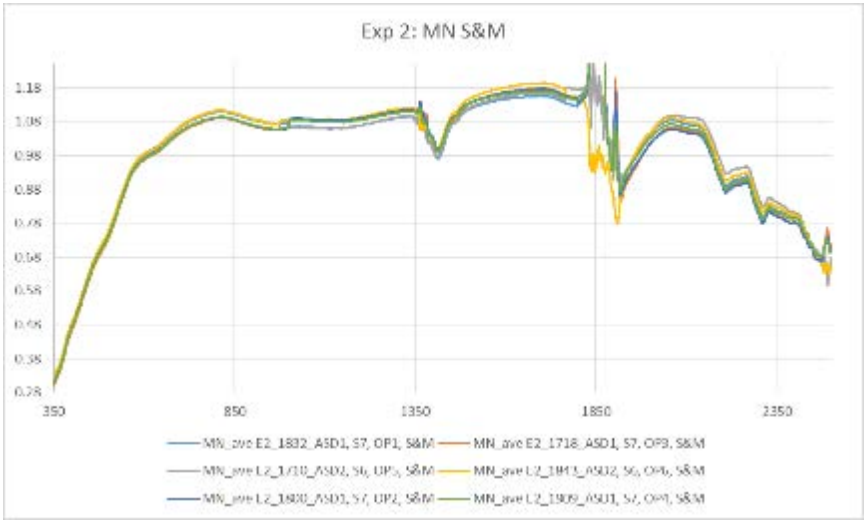
Experiment 2: Stop and measure vs continuous

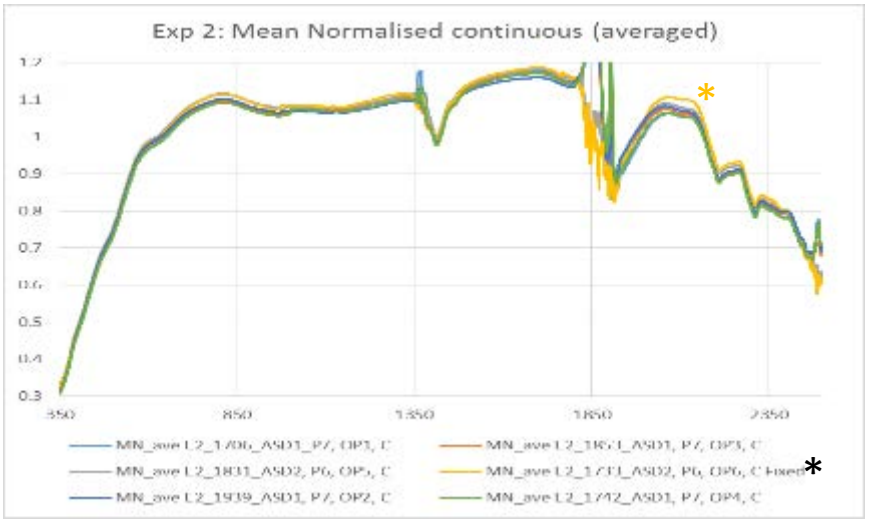
- Un-normalised data shows a range of reflectance of 3-5%.
- Differences in the average reflectance spectra between the S&M vs Cont. measurements.



Experiment 2: Stop and measure vs continuous

- Mean-normalised data shows similar results for each run regardless of the sampling method used for the 80 m transect.

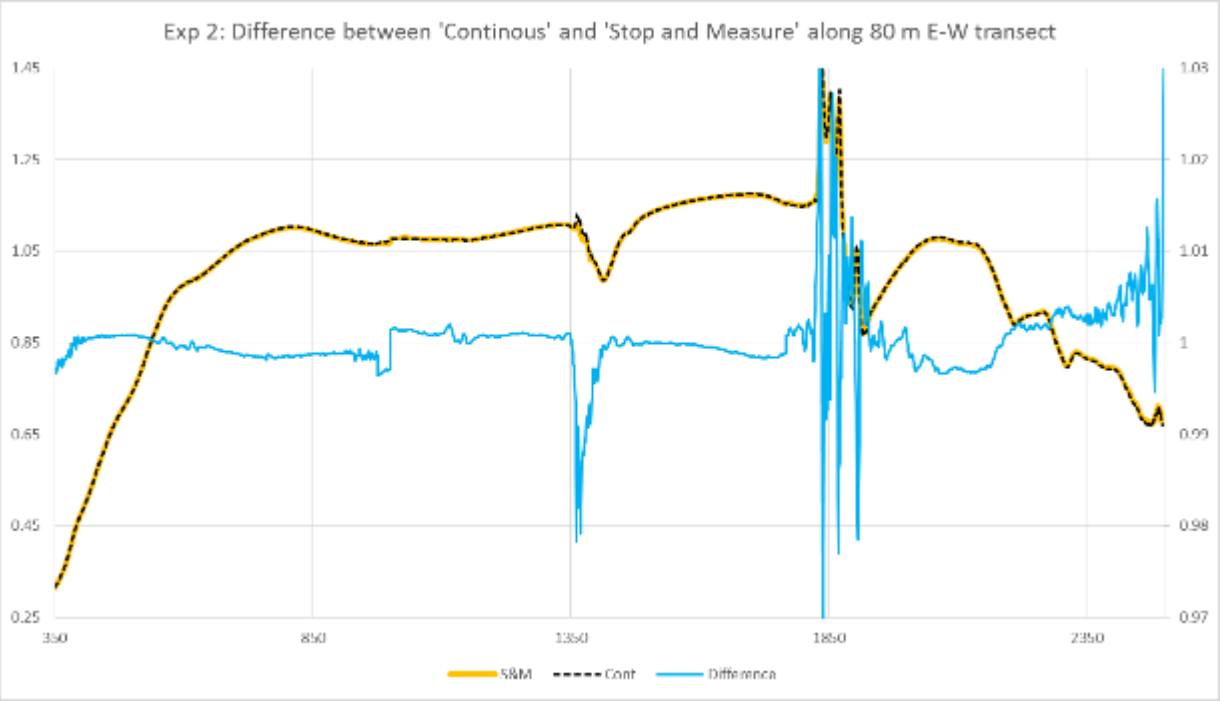




* Saturation occurred during sections of this run. Data was omitted.

Experiment 2: Stop and measure vs continuous

- Plotting the average mean-normalised Stop and Measure with the mean-normalised Continuous measurements shows they are very similar, as shown by the difference plot between the two methods for Experiment 2.



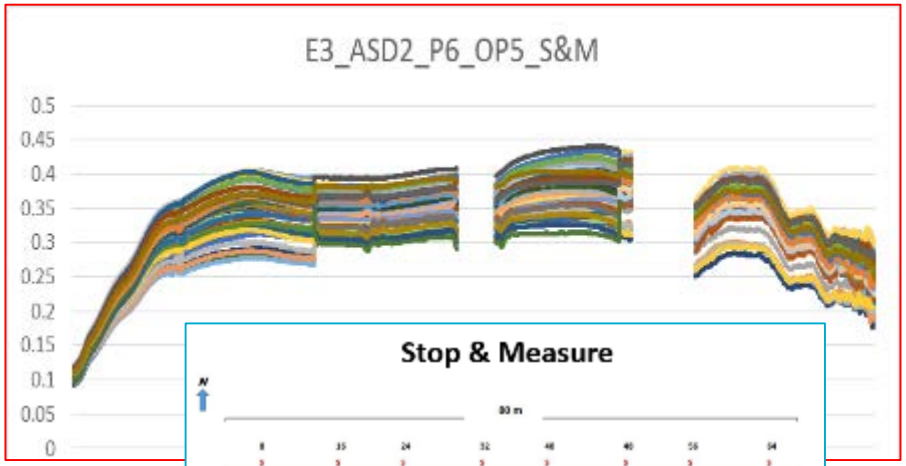
Experiment 2: Saturation on panel at end of scan

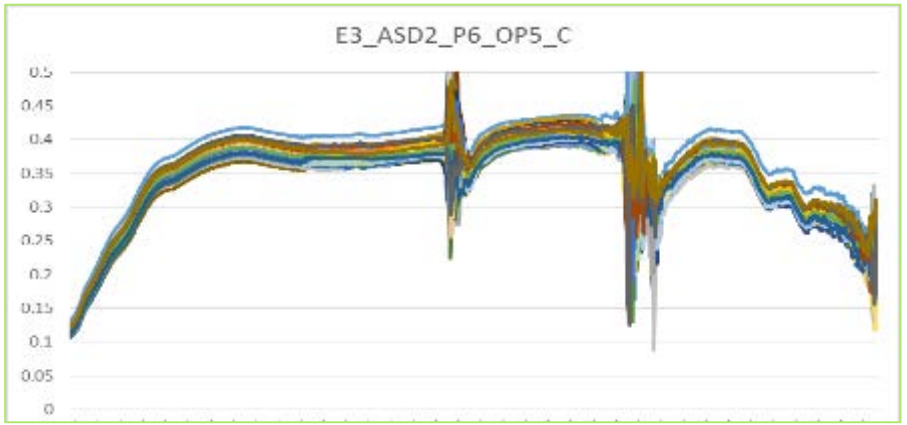
- Found to occur with older ASD (also instrument had heat related operating issues)

Experiment 2: Coefficients of variance

- The CV and SD for each of the individual Stop and Measure collects were low, but the variance between all of the measurements of the whole run of the 8 points was higher than the CV of the continuous method.

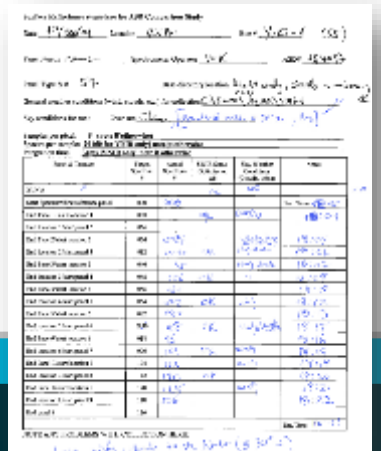
Method	CV %
Step and Measure	5.63
Continuous	2.73





Experiment 2: Coefficients of variance

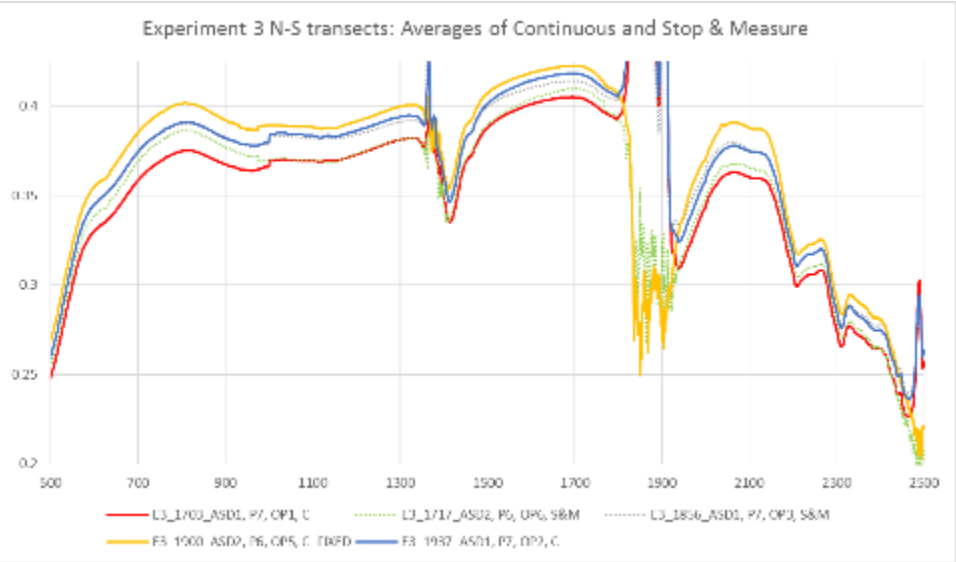
- CVs decreased for continuous measurements throughout the experiment, whereas CVs increased for the S&M measurements
- Field note sheets indicate the presence of wind and haze in the later measurements.

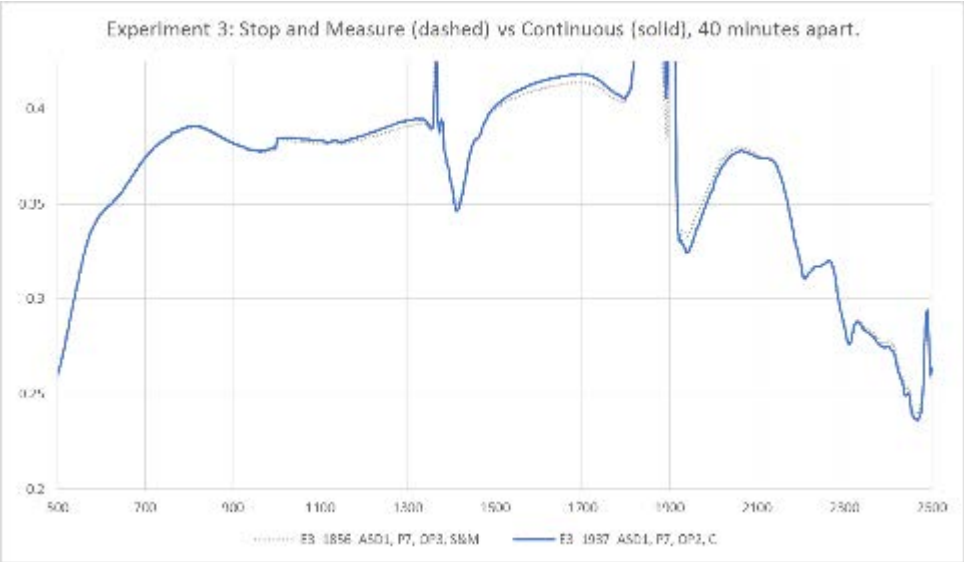


Run	Code	CV %
1	E2_1706_ASD1_P7_OP1_C	4.26
2	E2_1710_ASD2_P6_OP5_S&M	5.63
3	E2_1718_ASD1_P7_OP3_S&M	5.45
4	E2_1733_ASD2_P6_OP6_C	4.34
5	E2_1742_ASD1_P7_OP4_C	4.32
6	E2_1800_ASD1_P7_OP2_S&M	4.98
7	E2_1831_ASD2_P6_OP5_C	2.73
8	E2_1832_ASD1_P7_OP1_S&M	6.42
9	E2_1843_ASD2_P6_OP6_S&M	6.15
10	E2_1853_ASD1_P7_OP3_C	3.21
11	E2_1909_ASD1_P7_OP4_S&M	6.33
12	E2_1939_ASD1_P7_OP2_C	2.75
	Average	**4.71**
	Average S&M	5.88
	Average Continuous	3.60

Experiment 3: Comparison at the Cal val site

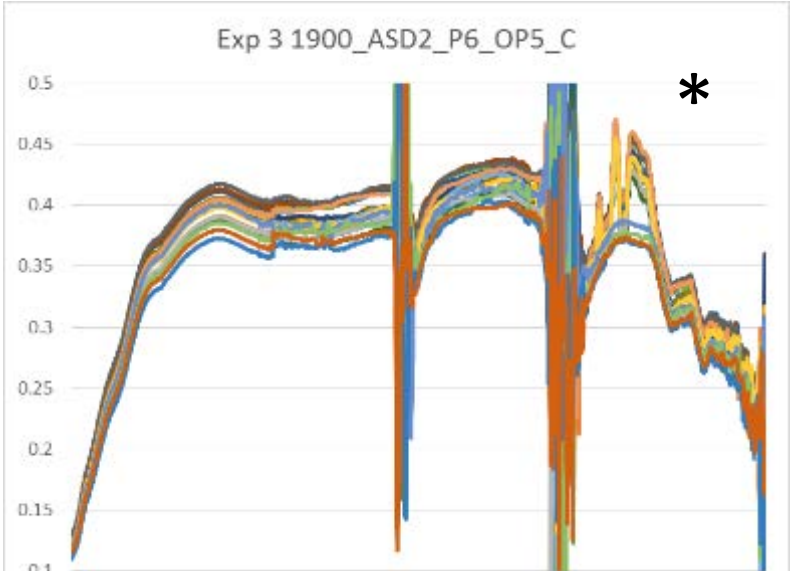
- Larger area of measurement (80 x 220 m), therefore less runs were collected.
- Cloudy conditions in the afternoon hindered the collection. Only 5 runs were made.
- Older spectroradiometer started to overheat, limiting the number of concurrent runs.
- Good agreement between step and measure and continuous data for ASD1.





Experiment 3: Saturation during two transects

- Older ASD exhibited problems.
- Example of spectra from Transects 2 and 3.
- No optimisation was done on the panel after transect 2.
- Cirrus clouds may have changed light conditions causing the spectroradiometer to saturate on the panel
- Removed the two transects with saturated data.



Taken from the field note sheets:

OVER for COLLECTION NOTES

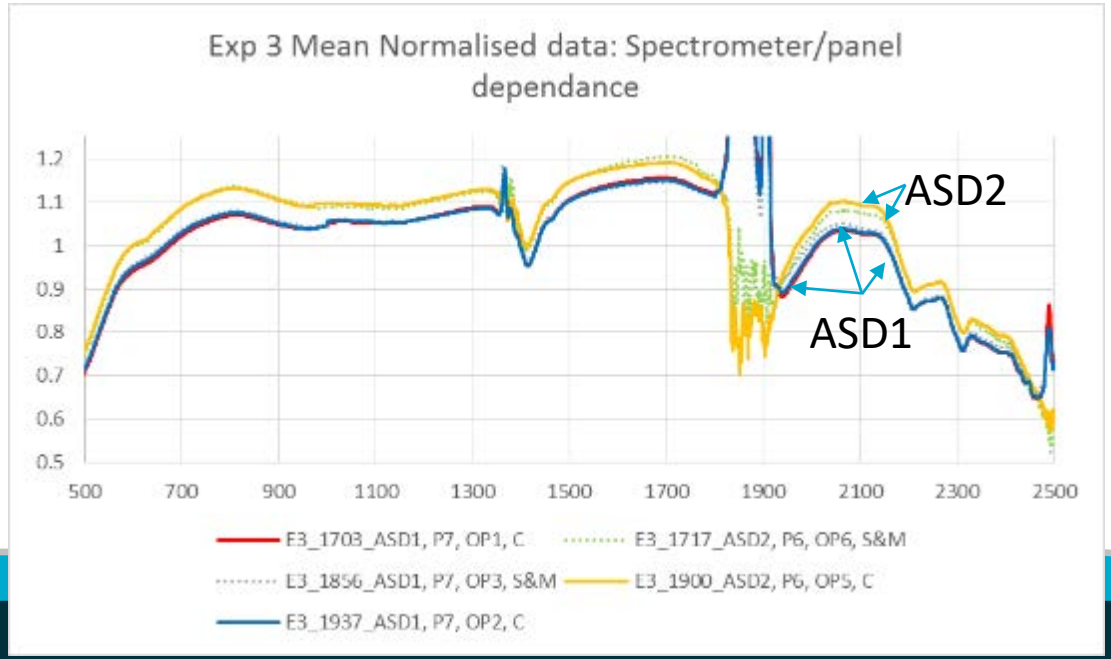
Panel & Transect	Target Spectrum #	Actual Spectrum #	SWIR Stats Optimize or Ok	Sky, Weather Conditions (Clouds, Wind)	Notes
Start Spectrum	000	000	ok	clear #1	Start Time: 19:00
End Panel	068	068		clear	
End Transect 2-Start Panel 2	072	072			
End Panel 2-Start Transect 3	080	080			
End Transect 4-Start Panel 3	144	144			
End Panel 3-Start Transect 5	152	152/160	opt	clear #3	optimize 152

General weather conditions (wind, clouds, etc.) for collection: Thin layer of cirrus clouds over sun. Scattered clouds around the sun.

Sky conditions at overpass: Over sun almost clear except for thin layer of cirrus clouds

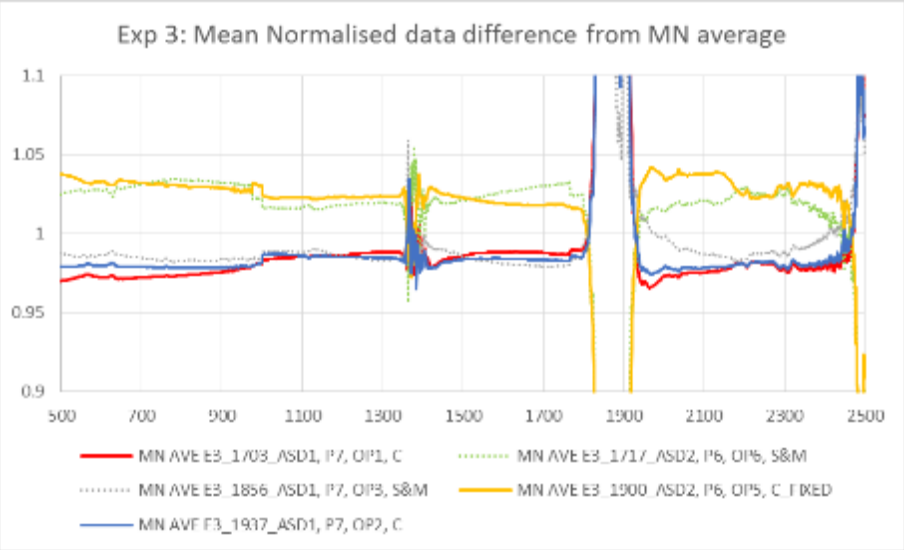
Experiment 3: Mean normalisation of data

- When the data is mean normalised, the spectra of the different spectroradiometers plot together, with Stop & Measure and Continuous data producing similar average spectra.



Experiment 3: Mean normalisation of data

The difference plots from the average of all of Exp3 measurements shows a similar grouping, with greater variation in the S&M and Continuous spectra in the SWIR2 region (1900 - 2500 nm).



Experiment 3: Coefficients of variance

- Average CV values were higher for Exp3 than Exp1 or Exp2.
- Measurements were interrupted by clouds.
- Only 5 runs were collected.
- Conditions were much more windy that previous days experiments.
- Continuous measurements took ~20 minutes. Whereas S&M took ~35 minutes.

Run	Code	CV %
1	E3_1703_ASD1, P7, OP1, C	4.79
2	E3_1717_ASD2, P6, OP6, S&M	8.07
3	E3_1856_ASD1, P7, OP3, S&M	5.77
4	E3_1900_ASD2, P6, OP5, C	3.44
5	E3_1937_ASD1, P7, OP2, C	4.03
	Ave CV	**5.22**
	Ave S&M CV	6.92
	Ave Cont CV	4.09

Conclusion

- Field sheets were useful for looking back at the conditions or when anomalies were found in the data.
- Meteorological, AERONET and transfer radiometer data needs to be examined in detail.
- Stop and Measure method allows control to remove bad spectra and can better characterize the surface, but less area can be measured in a restricted time, such as a satellite overpass. Thus, this technique may be useful for surface characterization of an area in good conditions.
- Solar irradiance variations can be observed in the samples, but the influence of pointing cannot be discarded as a possible source of variability.
- The exercise proved highly successful at demonstrating the procedure of field measurement for satellite cal-val measurements.

CSIRO ENERGY
Dr Cindy Ong
Principal Research Scientist

t +61 8 6436 8677
e cindy.ong@csiro.au
w www.csiro.au/